is, for small values of λT, virtually identical with Planck's more complete equation,

$$I_\lambda = C_1 \lambda^{-5} [e^{c_2/\lambda T} - 1]^{-1},$$

the author has taken Wien's equation and, by the method of least squares, determined the constants in such a way as to give the best representation of his results for the Hefner lamp. The differences between observed and computed values do not appear to exceed the experimental errors. In these computations the temperature T is assumed to be constant, and the equation

$$I_\lambda = 0.0160 \lambda^{-5} e^{-7.85/\lambda}$$

is found to represent the distribution of energy in the visible spectrum of the Hefner lamp.

Using Paschen and Wanner's value, $c_2 = 14440$, for a black body, and the value 7.85 obtained here, the "black temperature" of the Hefner flame is computed to be 1830° absolute. This value agrees sufficiently well with the temperature of a candle flame which, from Lummer and Pringsheim's experiments, is found, by using the generally accepted equation

$$\lambda_{\text{max.}} T = \text{constant} = k,$$

to lie between 1960° and 1750°, on the assumption that for candle flame, k lies between the values it has for a black body and for bright platinum, respectively.

At the end of the paper are two plates showing the instrumental arrangements and giving a graphical representation of the results.

This piece of research is not only valuable in its result, as giving us some definite idea of the energy curve of a common photometric standard, which will enable us to investigate other luminous spectra by photometric methods. It is also a good example of a rather complicated piece of work ingeniously carried through, and it is both interesting and instructive. It is interesting to know that, in form at least, Wien's black-body equation is applicable to the Hefner lamp for $\lambda < 0.76\mu$. Ångström's computation gives 1830° as the temperature a black body must have to give a spectral energy distribution identical in the visible region with that of the Hefner lamp, and the radiating carbon particles in the flame are probably, for $\lambda < 0.76\mu$, pretty nearly black. It would be interesting to have some direct measurement of the temperature of the flame as a whole, and to see how much higher it is than the "black temperature." We may fairly assume that it is higher, because the solid carbon particles, radiating faster than the gaseous portions of the flame, would naturally be cooler; and in the main, at any rate, it is these particles for which we are getting a temperature when we work by radiation methods.

It is advisedly that we say *a* temperature and not *the* temperature. Any calculation of the temperature of a body which is based on radiation involves some assumptions, unless the same temperature has also, at some time or other, been measured by some better established scale; at least, if our calculated temperature is expected to have any meaning in terms of the more familiar scale.

METEOR OF SEPTEMBER 15, 1902.

By E. L. MOSELEY, dated Sandusky, Ohio, May 4, 1904.

September 15, 1902, a remarkable meteor passed northward over Ohio, Ontario, and Michigan. As it passed before daybreak few persons were up early enough to see it. According to a boy who was up early to carry papers, the meteor of September 15 fell into Sandusky Bay about a quarter of a mile from him and he "heard the splash." A man, 5 miles east of the city, said it was "about 75 feet above the ground" when it passed near him. An observer in Cleveland thought it fell into Lake Erie about 5 miles north of the city. Near Meadville, Pa., some workmen "saw it fall in the woods," and a Pittsburg paper undertook to give its weight. By extensive correspondence and the insertion of letters of inquiry in many papers I have learned that it was seen throughout northern Ohio, from Defiance to Ashtabula; in southern Ohio, in Pike, Perry, Morgan, and Washington counties; in western Pennsylvania, at Erie, Edinboro, and Meadville; in New York, at Westfield; in Indiana, at South Bend; in Ontario, at many places between Lake Erie and Lake Huron, also at Drayton and Arthur, east of Lake Huron; in Michigan, at Detroit, Port Huron, Ann Arbor, Lansing, and a number of other places in that part of the State; also in Osceola County about 240 miles west of Arthur, Ontario. So far my efforts to learn of observers in West Virginia or in Michigan north of Saginaw Bay have been unavailing. This, however, does not indicate that the meteor fell into Saginaw Bay, as observers south of that bay thought, or into the southern part of Lake Huron, as observers south of that lake thought. The weather map issued that morning shows cloudy sky at stations in the northern half of Michigan, also in a part of West Virginia, but over most of this portion of North America the sky was clear.

APPEARANCE AND SOUNDS.

The meteor passed over eastern Ohio and southwestern Ontario at about 5:42 a. m., eastern standard time. According to most observers it continued visible between ten and thirty seconds. It was egg-shaped or pear-shaped, with the large end in front. To many it appeared to have about half the diameter of the full moon, but was much brighter, giving probably several times as much light as the full moon. The color was like that of an arc light, white or with a slightly bluish or possibly purplish tinge.

At Waverly, in southern Ohio, a rumbling sound was heard, but correspondents in southeastern Ohio do not report any sound. At many places in northern Ohio sounds were heard, but not very loud. At Defiance, from which the meteor, when nearest, was 160 miles distant, four observers interviewed by Dr. C. E. Slocum heard "a hissing noise." An observer near Sandusky heard "a slight hissing noise about as loud as a bee." M. F. Roberts, directly under the meteor at Mentor, heard "a rushing sound," which also attracted his wife's attention.

In Michigan, E. J. Smith and W. Kearns, at Detroit, heard "a loud sizzling noise." Near Port Huron an observer reported by C. K. Dodge heard "a great crackling and hissing, supposing at first it was his stove."

In Ontario, Andrew Smale, of Union, compared the noise to "that of an electric car running." The noise was heard by a number of persons in and near London, Ontario. J. B. McMurphy says of the sounds, "first like the swish of a falling tree, then changing to a noise similar to the striking of a parlor match on some hard surface with not quite sufficient force to ignite it, but enough to make it snap. It was something like this—bir-rup-bir-rup-bir-rup, then changing to a sound like distant cannon. There were three such sounds as those. All those sounds were as if they had been produced from an echo and reproduced several times, each time growing fainter."

The greater intensity of the sound in Canada than in Ohio I suppose was due to the fact that the meteor was then moving through air not so rare as where it first became visible. The sound seems to have been no more noticeable directly under the meteor than many miles either side of its path.

DURATION AND EXTENT OF THE TRAIN.

The train left by the meteor was observed by many who were not up early enough to see the meteor itself. Geo. D. Berry, near Marietta, Ohio, estimated that it remained visible between five and eight minutes, but all observers farther north who kept watch of it give a longer time, quite a number giving fifteen minutes or twenty minutes or until daylight. C. K. Dodge, of Port Huron, who is doubtless correct, reports it visible there for more than half an hour. The Pontiac reporter of the Detroit Tribune says "for at least half an hour." J. B. McMurphy, of London, Ontario, assures me that there the train was still visible sometime after sunrise and about an hour and a half after the meteor passed.

As seen from Ypsilanti, Mich., the train extended so far from south to north that Mrs. F. K. Owen, looking out of an east window, was unable to see either end of it. As seen at Port Huron it extended quite to the horizon at a point a little west of north.

At first the train formed an even curve or, as seen from some places, nearly a straight line, but in a few minutes it began to be sinuous and gradually became quite zig-zag, as described by a number of observers.

J. B. McMurphy writes from London, Ontario: "The sparks were very numerous and about the color of ordinary fire sparks. Later they appeared gray like ashes." Others speak of the train as "white," "a light streak," "lead-colored streak," "phosphorescent glow," "color of full moon on a clear night;" Mrs. Owen, at Ypsilanti, "a band of shining light, silvery white, brighter toward the north, faded toward the south;" D. C. Johnson, at Marblehead, Ohio: "Sparks appeared to turn to white ashes that stayed until the wind blew them away."

PATH.

At Somerset, Perry County, Ohio, several observers interviewed by Chas. W. Cookson, saw the meteor pass to the east, about halfway between zenith and horizon. At Alliance, Stark County, Ohio, Prof. B. F. Yanney reports, but not from personal observation, that the meteor was first seen near the zenith. Observers at Cleveland and farther west saw it pass them on the east, though in eastern Cleveland it appeared not many degrees from the zenith. After many attempts to find an observer not far east of Cleveland, I heard through Mary E. Mathews, of Lake Erie College, of an observation made by Marcus F. Roberts and wife. He wrote that the meteor "passed directly over Mentor village at a point between Heart and Center streets." After sending him my first article on the meteor, published in Popular Astronomy, I wrote inquiring whether the meteor seemed to pass *exactly* over him or whether it seemed to pass over a point near him. He replied: "The meteor did not seem to be exactly overhead, but a little to the west."

In Ontario, George M. Tupholme, of Ridgetown, replied to a similiar question: "The meteor passed a very slight point to the west of me, nearly overhead." According to J. B. George, quoted by J. B. McMurphy, "it passed almost directly overhead," he being that morning at Croton. At Sarnia, Mrs. D. McLaren says: "I think that the meteor was a little east of Sarnia, judging by the trail, but my first impression was that it had passed exactly overhead; it looked so as it sped on its way northward. A neighbor of ours also saw it. He thinks, too, that it was a little east of Sarnia." C. K. Dodge, a customs officer at Port Huron, Mich., writes: "My office is situated west of the city of Port Huron, perhaps a mile and a quarter from a north and south line passing through the center of the city. This streak seemed to be to the east of my office and to pass directly over the city of Port Huron, or rather nearer to me than that. The deflection to the east from a perpendicular line where I stood would not be more than 15°. It seemed nearly overhead." If the zenith distance at Mr. Dodge's office was not more than 15° the meteor could not have passed much more than 4 miles east of Sarnia.

According to the maps at my disposal, the arc of a great circle passing 4 miles east of Sarnia and 6 miles west of Mentor passes 5 miles east of Alliance, 3½ miles west of Ridgetown and about 1 mile west of Croton.

ELEVATION.

Lewis Schwartz had just gone through his gate at Sandusky, when turning about he saw the meteor pass between the cross-arms of a telegraph pole. Standing in the same place some days afterwards he directed a ruler toward the opening between these cross arms while I held a card beside the ruler, with its lower edge horizontal, and traced upon it a line along the edge of the ruler. This gave an angle of 49½°. In like manner Harriet Clemons obtained the altitude of 44⅓° from D. C. Johnson at Lakeside, 7 miles north of Sandusky and about the same distance as Sandusky from the path of the meteor. Willard House, 5 miles south of Sandusky, also about the same distance from the path of the meteor, estimated the altitude at 45°, but this was merely an estimate. The first of these determinations is likely to involve the least error, because Mr. Schwartz although young and without knowledge of astronomy, had the means of recalling his position probably within a foot or two, and also the place where the meteor crossed the telegraph pole. If we adopt 47° as the highest apparent altitude reached by the meteor as seen from Sandusky we will probably not have it too high nor much too low. This corresponds to an elevation of 73 miles when the meteor was east of Cleveland. That this result is not far from correct is shown by an analysis of reports obtained from Defiance through the efforts of Dr. C. E. Slocum. Three witnesses interviewed by him agreed "that it was about one-third, possibly more, of the distance between the horizon and zenith." A fourth witness at the time of observation was driving east and had gone about 7 miles from Defiance. He estimated that the meteor was about one-fourth the distance to the zenith. Inasmuch as persons are likely to overestimate distances near the horizon, and inasmuch as the fourth witness was an intelligent man and had ample opportunity to observe the meteor and its train, his estimate is likely to be more nearly correct than that of the first three. Later, Dr. Slocum found that J. F. Heilshorn, a voluntary weather observer, living 4½ miles east of Defiance, had measured the altitude and found it 23°. From correspondence with J. F. Heilshorn, after he had removed from Ohio, I learned that he did not see the meteor itself but saw the train, and later got the angle by means of a branch of a tree. His brother, Harry Heilshorn, saw the meteor pass. He is still on the place, and at my request he sent me a drawing of the angle. This measured 23°. From further correspondence I infer that he does not consider this reliable to nearer than one or two degrees. The plane of this angle passes through Sandusky or very near it. An elevation of 73 miles corresponds to an altitude a trifle less than 24° at Mr. Heilshorn's place.

In Ontario, J. B. McMurphy, 7 miles west of London, measured the least zenith distance with a quadrant and found it 35°. This was several days after the meteor had passed, but is probably correct within two or three degrees. A zenith distance of 35° at a distance of 40 miles from the track of the meteor corresponds to an elevation of about 38½ miles. A line from London to Detroit intersects the meteor's track nearly at right angles.

At Detroit, E. J. Smith and W. Kearns were together when they saw the meteor, also when I interviewed them a year later. When asked if the meteor was half way up from horizon to zenith, they had no hesitation in saying "more than half way." Now, an elevation of 58½ miles corresponds to an angle of about 46° at Detroit; so it is not probable that the elevation between Detroit and London was less than 58½ miles.

To Lewis Schwartz, at Sandusky, the meteor seemed to strike the water of Sandusky Bay close to the corner of a certain dock. From this I found that the place of disappearance was 14° west of the meridian. A line drawn in this direction intersects the track of the meteor in Algona County, Mich., 200 miles north of the Ohio boundary.

Reports from Defiance regarding the point of disappearance, though not definite, lead me to think that there, also, the meteor remained visible until it had gone about 200 miles north of the Ohio boundary. It must have passed a little west of Alpena and between Mackinaw and Sault Ste. Marie if it continued so far without change of course. It probably passed nearly over Steubenville, Ohio, and between Wheeling, W. Va., and Washington, Pa.; but as yet I have not learned of its having been seen at any of these places or at any place near them.

If those persons who are fortunate enough to witness the passage of such a great meteor would note carefully the point of disappearance in reference to chimneys, houses, trees, poles, etc., and their own position at the time of observation, it would facilitate the determination of the path. If the meteor leaves a bright train of sparks behind it, then the observer, by walking a few steps, should at once get the highest part of the train in line with the top of a chimney or some other permanent object that can be identified at any future time, and then note accurately his own position, so that ultimately the exact azimuth and altitude can be determined. If the meteor is seen to burst, its altitude and azimuth at that moment should be determined as accurately as possible.

If we have a large number of well observed altitudes, azimuths, and the times of first and last appearance, or the time and position of the maximum apparent altitude of the meteor, then the astronomer can determine quite accurately the absolute altitudé, the speed in miles per second, and the orbit of the meteor relative to the earth and the sun. A number of meteors have been thus investigated. Many of the largest have been shown to pass through our atmosphere and continue on in their courses through planetary space.

Such a large number of minute meteors, ordinarily known as shooting stars, are burned up in the atmosphere daily as to constitute a slight, barely appreciable source of heat and dust. The result is not considered as of any importance to current meteorology, but the accumulation of meteoric dust through long geologic ages may have an important relation to both the earth and the atmosphere.—ED.

RECENT PAPERS BEARING ON METEOROLOGY.

Dr. W. F. R. PHILLIPS, Librarian, etc.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers or other communications bearing on meteorology or cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled; it shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau. Unsigned articles are indicated by a ——.

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Archenhold, F. S. Die Temperatur der Luft über Berlin. Pp. 272-273.

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—— Meteorologischen Beobachtungen, angestellt in Yap (Karolinen) vom 1 Dezember 1899-22 Juni 1900, von Prof. Dr. G. Volkens. Pp. 193-194.
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—— Regenfall zu Sucre (Bolivien). P. 196.
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